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LINYPHIA TRIANGULARIS, A PALEARCTIC SPIDER (ARANEAE, LINYPHIIDAE) NEW TO NORTH AMERICA

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ABSTRACT. A Palearctic spider, *Linyphia triangularis* (Clerck 1757), has been accidentally introduced to the U.S.A. and populations successfully established in Maine. The date, origin, and focal point(s) of introduction are unknown, but suspected to be recent, European, and maritime. Extensive historical collections, records of maritime commerce, and recent chronological collections support this hypothesis. Results of cursory surveys in 1999 and 2000 indicate that *L. triangularis* is now widely distributed in Maine with specimens taken in 15 of 16 counties. The potential impact(s) of *L. triangularis* on the native araneofauna are unknown, but possibly detrimental. In Europe, this species exhibits aggressive behaviors (e.g., web "take-overs") toward conspecifics and congenerics.

Keywords: Introduced species, Maine spiders, aggressive linyphiid, recent invasions

Spiders are dispersed over great distances by aerial ballooning and by human transport (Gertsch 1979; Kaston 1983). Several species have been implicated as immigrants to North America from Europe and elsewhere; common examples include *Araneus diadematus* Clerck 1757, *Salticus scenicus* (Clerck 1757), *Pholcus phalangioides* (Fuesslin 1775), *Achaearanea tepidariorum* (C.L. Koch 1841), *Tegenaria domestica* (Clerck 1757), and *Dysdera crocota* C.L. Koch 1838 (Gertsch 1979). More recently, the northeastern United States and Canada have seen introductions of *Steatoda bipunctata* (Linnaeus 1758) from Europe (Nyffeler et al. 1986), and of *Achaearanea tabulata* Levi 1980, possibly from Asia (Dondale et al. 1994). In California, Griswold & Ubick (2001) noted the introduction of *Zoropsis spinimana* (Dufour 1820), a native to the Mediterranean region. Here we describe the invasion and establishment of yet another exotic spider in North America, i.e., *Linyphia triangularis* (Clerck 1757), which presumably is an immigrant from Europe.

Chronology of discovery.—During 1991, 1996, and 1997, F. G., Jr. collected female linyphiid spiders in old field vegetation at Milbridge, Washington County, Maine. Subsequently, D. T. J. determined the specimens to be *Linyphia triangularis* (Clerck 1757), a Palearctic spider. Peter J. van Helsdingen of the National Museum of Natural History in Leiden confirmed the species identity.

The abundance of *Linyphia triangularis* in Maine became evident when 9 males, 20 females, and 2 juveniles were readily taken on 19 August 1998 at Schoodic Peninsula, Acadia National Park, Winter Harbor, Hancock County. Our suspicion that *Linyphia triangularis* had successfully established a breeding population at Schoodic Peninsula was confirmed on 19 August 1999, when 5 males and 18 females were taken in < 2 h at the same site sampled in 1998. Most were found in slightly dome-shaped webs on understory forbs (*Solidago* sp.), grasses, ferns, and shrubs near the ground; a few were taken by beating and sweeping lower-crown foliage of red spruce, *Picea rubens* Sargent, and by search-

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ing loose bark and tree boles of paper birch, *Betula papyrifera* Marshall.

Males and females were observed cohabitating in the same web; however, mating and oviposition were not observed either year.

Associated species of sheet-line weavers (Linyphiinae) at Schoodic included: adults of *Bathyphantes pallidus* (Banks 1892), *Centromerus denticulatus* (Emerton 1909), *Drapetisca alteranda* Chamberlin 1909, *Helophora insignis* (Blackwall 1841), *Lepthyphantes calcaratus* (Emerton 1909), *L. turbatrix* (O.P.-Cambridge 1877), *Microneta viaria* (Blackwall 1841), *Neriene radiata* (Walckenaer 1841), and *Tapinopa bilineata* Banks 1893; and juveniles of *Frontinella*, *Helophora*, *Neriene*, and *Pityohyphantes*. Based on collection frequency, none of the associated adult linyphiids (n = 18) was as common as *Linyphia triangularis* in 1998; none of associated adult or juvenile linyphiids (n = 19) was as common as *L. triangularis* in 1999.

Prior collections.—None of the contacted museums or institutions had records of *L. triangularis* collected in Maine or elsewhere in North America. These included: The American Museum of Natural History (AMNH), New York; California Academy of Sciences (CAS), San Francisco; Canadian National Collection (CNC), Ottawa; Field Museum of Natrural History (FMNH), Chicago; Harvard Museum of Natural History (HMNH), Cambridge; Thomas Burke Museum (TBM), Seattle; and, U. S. National Museum of Natural History (NMNH), Washington.

Procter (1946) listed 15 families, 94 genera, and 179 species of spiders collected from various habitats on Mount Desert Island, Hancock County, Maine. *Linyphia triangularis* was not among them.

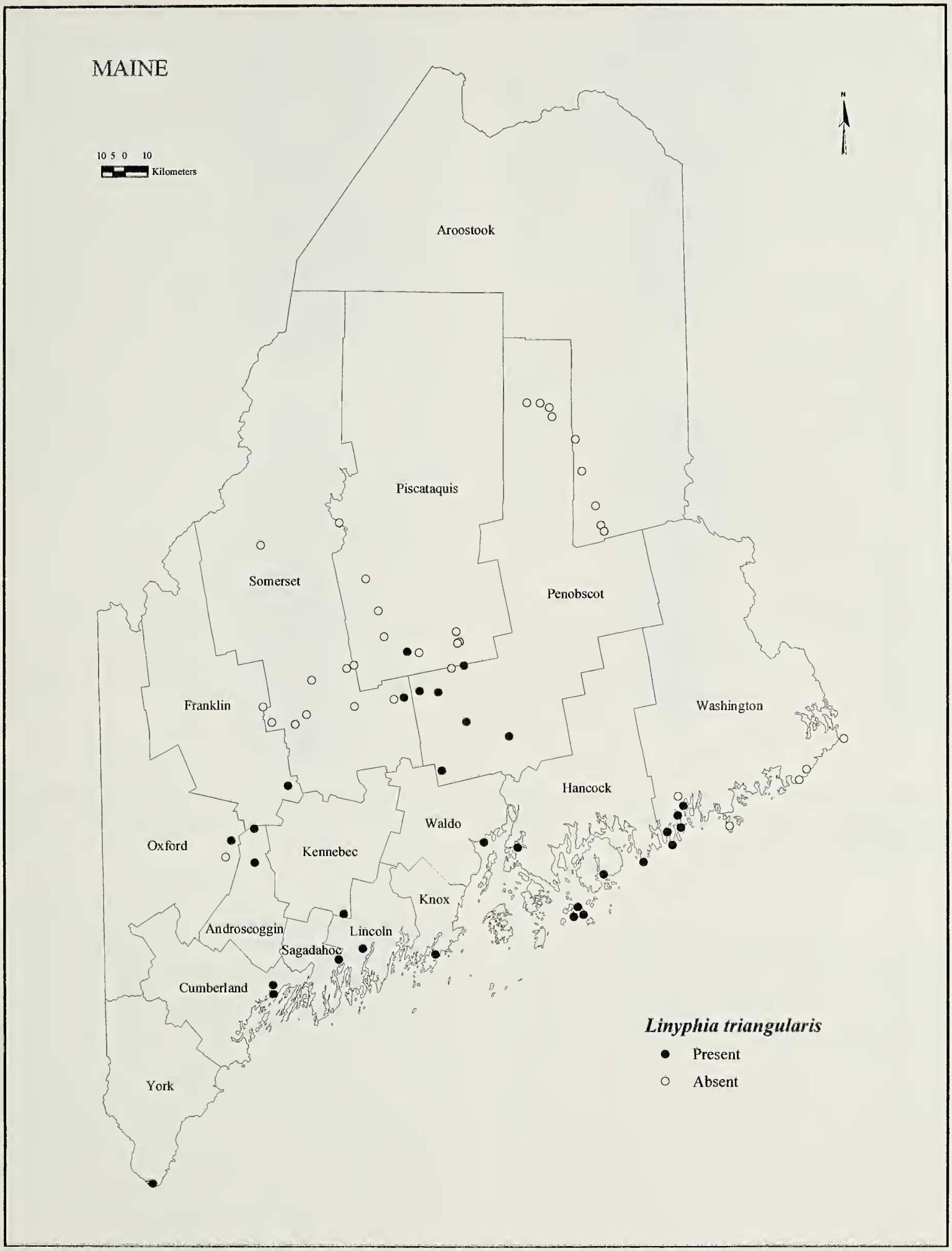
Examination of D. T. J.'s undetermined material yielded 7 males and 10 females of *L. triangularis* collected during August of 1983, 1986, 1989, and 1994, and from the counties of Cumberland, Hancock, Penobscot, and York (Map 1). The earliest record of *L. triangularis* in Maine is a female taken 28 August 1983 at Stover Corner, Brooksville, Hancock County, Maine.

Survey results.—During August–September, 1999, 15–20 minute searches were made at numerous localities and among diverse habitats in rural Maine. The survey yielded 64 specimens of *L. triangularis* from the counties of Androscoggin, Franklin, Kennebec, Knox, Lincoln, Oxford, Penobscot, Piscataquis, Sagadahoc, Somerset, and Waldo (Map 1); none were found in Aroostook County. Additional searches during August–September, 2000, failed to yield specimens of this exotic spider in mid, northern, and far "downeast" Maine (Map 1). Of Maine's 16 counties, only Aroostook County remains to yield specimens of *L. triangularis*. The chronological and geographic distributions of our records suggest that the species might be moving inland from a coastal locus or loci. Thus far, *L. triangularis* has not been found in Quebec (Paquin et al. 2001) or in New Brunswick (Buckle et al. 2001).

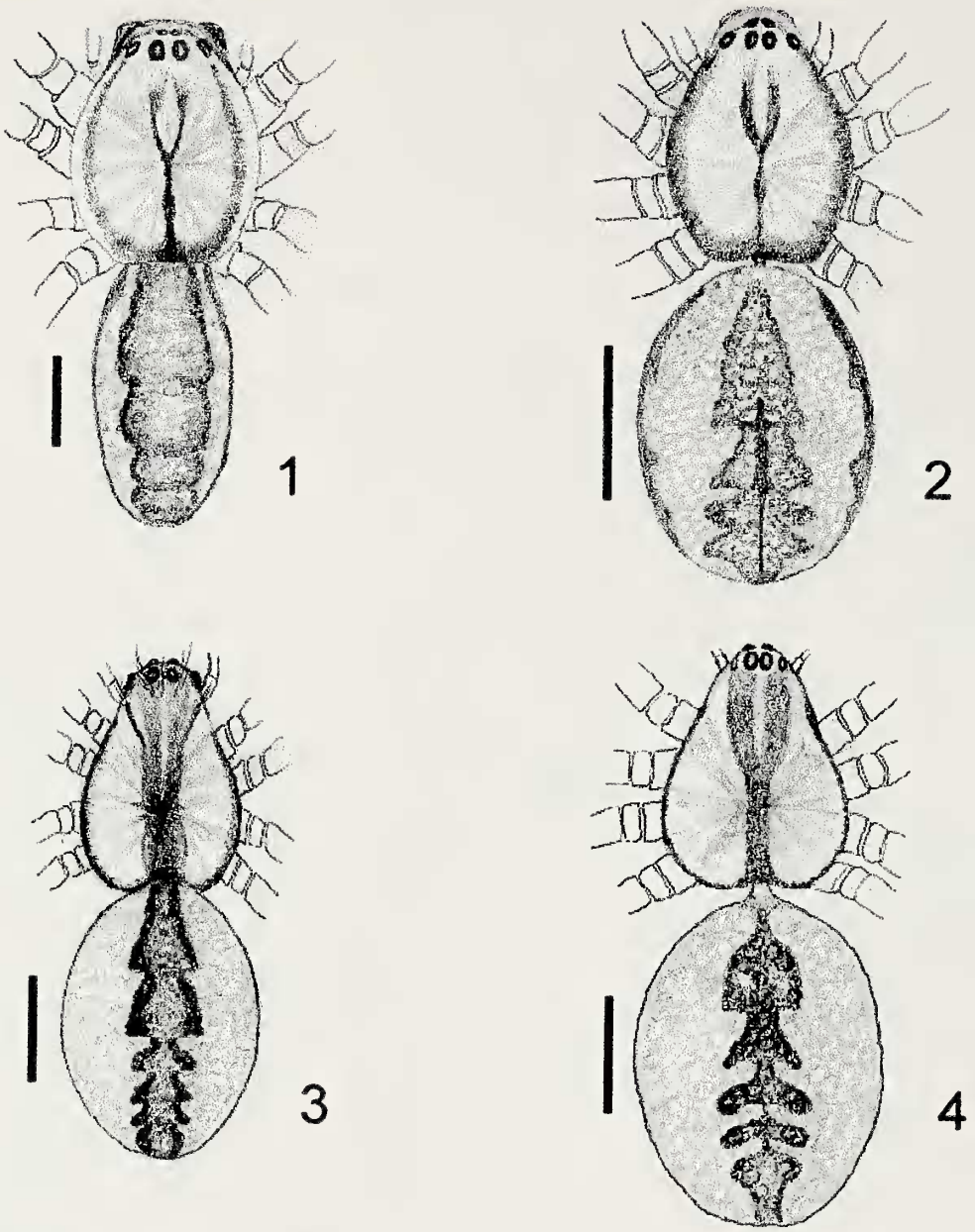
Introductory date, origin, & mode.—The actual date of arrival, source or origin of emigration, and mode of travel are unknown. Historical collections of spiders in New England provide some evidence that *Linyphia triangularis* arrived recently (i.e., within the last half-century) in Maine. In the late 1800's and early 1900's, James H. Emerton and Elizabeth B. Bryant collected spiders in Maine and other New England states, but none of their published lists (see Bonnet 1945) include *L. triangularis*. During the last half-century, spiders have been collected extensively in New England and the Maritime Provinces; e.g., Charles D. Dondale, James H. Redner, and associates in Ontario, Quebec, New Brunswick, and Newfoundland; Robert L. Edwards in Cape Cod, Massachusetts; Benjamin J. Kaston in Connecticut; and Herbert W. Levi in Massachusetts, New Hampshire, Maine and other New England states. None of these collections yielded specimens of *L. triangularis*.

Prior to the discoveries in Maine, the known geographic distribution of *L. triangularis* included the Palearctic region from southern, western, and northern Europe to Siberia and China in the east (Helsdingen 1969). The species is very common in the British Isles (Locket & Millidge 1953) and in Scandinavia (Nielsen & Toft 1990). With the recent expansion of worldwide commerce, any one or more countries in the Palearctic region could serve as the origin(s) of emigration of *L. triangularis* to North America.

Description, webs, and life history.—Descriptions and illustrations of *Linyphia triangularis* are provided by Helsdingen (1969) and Roberts (1993, 1995), and include illustrations of the male and female genitalia. The



Map 1.—Distribution of collection and survey sites in Maine for the Palearctic sheet-line weaver, *Linyphia triangularis* (Clerck, 1757). Closed circles, *L. triangularis* present, all data inclusive (1983–2000); open circles, *L. triangularis* not present in 1999 or 2000.



Figures 1–4.—Dorsum of carapace and abdomen. 1, 2. *Linyphia triangularis* collected in Maine. 1. Male; 2. Female; 3, 4. *Pityohyphantes* sp. collected in Maine. 3. Male; 4. Female. Scale bars = 1 mm. (Drawings by N. Sferra).

color pattern of *L. triangularis* closely resembles that of the North American *Pityohyphantes costatus* (Hentz 1850); dorsally, both species have a bifurcated, "tuning-fork" marking on the carapace, and a herring bone pattern on the abdomen (Figs. 1–4). The latter is less evident in *L. triangularis* males (Fig. 1). The markings of *L. triangularis* also resemble those of *P. phrygianus* (C. L. Koch 1836), another European immigrant in Maine, but less common than *P. costatus*. Ventrally, the femora of *L. triangularis* are devoid of dark spots, while black or dark-brown spots are usually present on the femora of *P. costatus* and *P. phrygianus* (*cf.* Roberts 1993, Part 2, plates 231 & 233). Unlike *Pityohyphantes*, the tuning-fork markings do not extend to the posterior eye rows in *L. triangularis* (Figs. 1–2).

The web of *L. triangularis* has been described and illustrated by Nielsen (1931), Bristowe (1958), Jones (1983), and Preston-Mafham (1984). It consists chiefly of a flattened sheet, slightly arched in the center, and held in place by scaffolding threads above and below the sheet. The web lacks a retreat, with the resident spider hanging upside-down near the center of the sheet. The webs of *L. triangularis* in Maine more closely resemble the webs of *Pityohyphantes* species than those of *Neriene radiata* (*cf.* Roberts 1995, p. 74).

The species is univoltine in Europe, over wintering as eggs in leaf-litter beneath trees and shrubs (Turnbull 1960). Juvenile spiderlings emerge from the egg sac in the spring (May), and reach maturity by late July or August (Toft 1978, 1989). Development is protandrous, with males reaching adulthood about a week earlier than females. The sexually mature males enter the webs of subadult females, where they remain until the female

reaches maturity (Toft 1989; Nielsen & Toft 1990). Shortly afterwards, mating takes place in the web (Herberstein 1997; Stumpf 1990), followed by oviposition in October or November (Nielsen & Toft 1990). The life history of *L. triangularis* in North America remains to be studied.

Potential impacts.—What are the potential impacts of *L. triangularis* on the native spider and insect faunas in Maine? Such impacts could be beneficial, neutral, or detrimental. In northern Europe, *L. triangularis* usurps the webs of conspecifics and congenerics (Toft 1987, 1990). Though native *Linyphia* species are absent in eastern North America (Helsdingen 1969; Buckle et al. 2001), *L. triangularis* could invade the webs of associated species such as *Frontinella communis*, *Pityohyphantes costatus*, or *Neriene radiata*. If so, will this alien spider compete with native species for microhabitat space and food, or are such resources sufficiently abundant to provide niche partitioning and species coexistence? Perhaps differences in developmental phenologies or other ecological-behavioral parameters will minimize impacts between invader and native species.

We suspect that biodiversity will be affected by this introduction. Collectively, invasion by exotics is the second most prevalent cause of species endangerment after habitat loss (Wilson 1992; Czech et al. 2000). For example, in some regions of northeastern North America, the native *Steatoda borealis* (Hentz 1850) has been displaced by the European *S. bipunctata* (Linnaeus 1758) (Nyffeler et al. 1986). Will native sheet-line weavers and other spiders be displaced by *L. triangularis*? These and other questions pose unique challenges to researchers and resource managers alike. See Cox (1999 & lit. cited) for a review of potential impacts of invasive exotics.

Linyphia triangularis meets 7 of the 8 criteria that characterize a successful invader (Ehrlich 1986), i.e., 1) abundant in original range; 2) polyphagous instead of monophagous or oligophagous; 3) short generation time; 4) fertilized female able to colonize alone; 5) larger than most relatives; 6) associated with *Homo sapiens*; and 7) able to function in a wide range of physical conditions. Only its genetic variability, compared to that of non-invaders, remains to be ascertained. Because this alien species is free from its natural enemies of origin, populations in Maine are apt to expand rapidly unless tempered by native parasites, predators, and pathogens.

We conclude that *L. triangularis* has successfully invaded and established breeding populations in Maine. The future of these populations and their potential impacts on Maine's diverse insect and spider faunas warrant further investigation.

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